

# REPORT DOCUMENTATION PAGE

Form Approved  
OMB No. 0704-0188

Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden to Washington Headquarters Service, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188) Washington, DC 20503.

PLEASE DO NOT RETURN YOUR FORM TO THE ABOVE ADDRESS.

1. REPORT DATE (DD-MM-YYYY) 31/12/2001		2. REPORT DATE Final		3. DATES COVERED (From - To) March 2000 - December 2001	
4. TITLE AND SUBTITLE  Advanced Modeling System for the Gulf of Mexico: Evaluation and Validation of the NRL-POM Relocatable Model				5a. CONTRACT NUMBER N00014-00-1-0551	
				5b. GRANT NUMBER N00014-00-1-0551	
				5c. PROGRAM ELEMENT NUMBER N/A	
6. AUTHOR(S)  Germana Peggion				5d. PROJECT NUMBER N/A	
				5e. TASK NUMBER N/A	
				5f. WORK UNIT NUMBER N/A	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)  The University of Southern Mississippi Southern Station Box 5157 Hattiesburg, MS 39406-5157				8. PERFORMING ORGANIZATION REPORT NUMBER  GR00526-Final  Fed. I.D.#64-6000818	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)  Office of Naval Research Ballston Centre Tower One 800 North Quincy Street Arlington, VA 22217-5660				10. SPONSOR/MONITOR'S ACRONYM(S)  ONR	
				11. SPONSORING/MONITORING AGENCY REPORT NUMBER	
12. DISTRIBUTION AVAILABILITY STATEMENT  Unlimited					
13. SUPPLEMENTARY NOTES  N/A					
14. ABSTRACT  A computationally robust, user friendly, and physically accurate modeling system has been implemented to provide short-term forecast capabilities in support of real-time Naval operations. MODAS nowcast provides initial and boundary condition for NRLPOM, a version of the Princeton ocean model. NRLPOM includes tidal forcings and has the capability to be coupled with other large-scale models and nesting between domains of different grid resolutions. The MODAS-NRLPOM prediction system has been evaluated in several areas and configurations.					
15. SUBJECT TERMS  Relocatable ocean model - real-time applications Model evaluation - model-model and model-data comparison					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE	UU	5	Germana Peggion
U	U	U			19b. TELEPHONE NUMBER (Include area code) 228-688-2897

20020806 094

# **Advanced Modeling System for the Gulf of Mexico: Evaluation and Validation of the NRLPOM Relocatable Model**

Germana Peggion

The University of Southern Mississippi  
Bldg. 1103, Rm. 249, Stennis Space Center, MS 39529  
phone: (228) 688-2897 fax: (228) 688-7072  
e-mail: [germana.peggion@usm.edu](mailto:germana.peggion@usm.edu)

Grant Number: N00014-00-1-0551

## **LONG-TERM GOALS**

The long-term objectives are to implement a user-friendly, computationally robust, and physically accurate modeling system to provide short-term forecast capabilities in support of real-time naval operations.

## **OBJECTIVES**

MODAS-NRLPOM is a scalable, portable, and rapidly relocatable system for nowcast and short term (2-day) forecast simulations. There are two major components: 1) the Modular Ocean Data Assimilation System (MODAS) to generate a nowcast field to initialize 2) the Naval Research Laboratory Princeton Ocean Model (NRLPOM).

The primary objective is to evaluate the operational system. There is a fundamental difference in assessing a predictive system in a research and in an operational mode. A research predictive system is designed, calibrated, and evaluated to encompass the dominant dynamics of a given region. The goal is to provide the *most accurate* representation of the dynamical features of a *specific* area. A predictive system, which supports operational applications, must be rapidly relocatable anywhere in the ocean (oil-spill and naval exercises are the most relevant applications), and easily reconfigured. The principal goal is to provide *good* representations *everywhere* with the available data (i.e., in spite of the lack of observations). In this respect, different metrics and criteria should define the evaluation of the two modeling approaches.

## **APPROACH**

Our work has focused on the evaluation of the physical accuracy of 1) MODAS nowcast and 2) NRLPOM forecast. The working hypothesis is that MODAS field is accurate enough to allow a dynamical model to spin up the correct physics in coastal and littoral regions. More specifically, we have performed real-time experiments and hindcast simulations in several areas and configurations, ranging from basin-scale to inlets, from deep to coastal domains.

## **WORK COMPLETED**

We have delivered to NRL the latest version of NRLPOM which includes new features implemented to increase the computer robustness and physical accuracy, such as: 1) initialization procedures, 2) tidal forcing, and 3) open boundary conditions (OBC).

## RESULTS

1) Initialization is based on cold/warm/diagnostic (and combination) procedures. The default is a cold start from MODAS with wind at -24/48 hrs. to build the mixed layer. The procedure is numerically robust, but less accurate since everyday starts from scratch. Moreover, the variability of coastal areas may be characterized by highly energetic, but short time-scale, features which make it difficult to assimilate into the MODAS nowcast knowledge of the ocean's past state. As Figure 1 illustrates, MODAS fields may tend to relax toward climatology, in the case of persistent cloud coverage. Therefore, NRLPOM includes an option (henceforth referred as to the long-run simulations) in which the forecast is from a warm restart from the previous day nowcast (not POM's typical restart procedure).

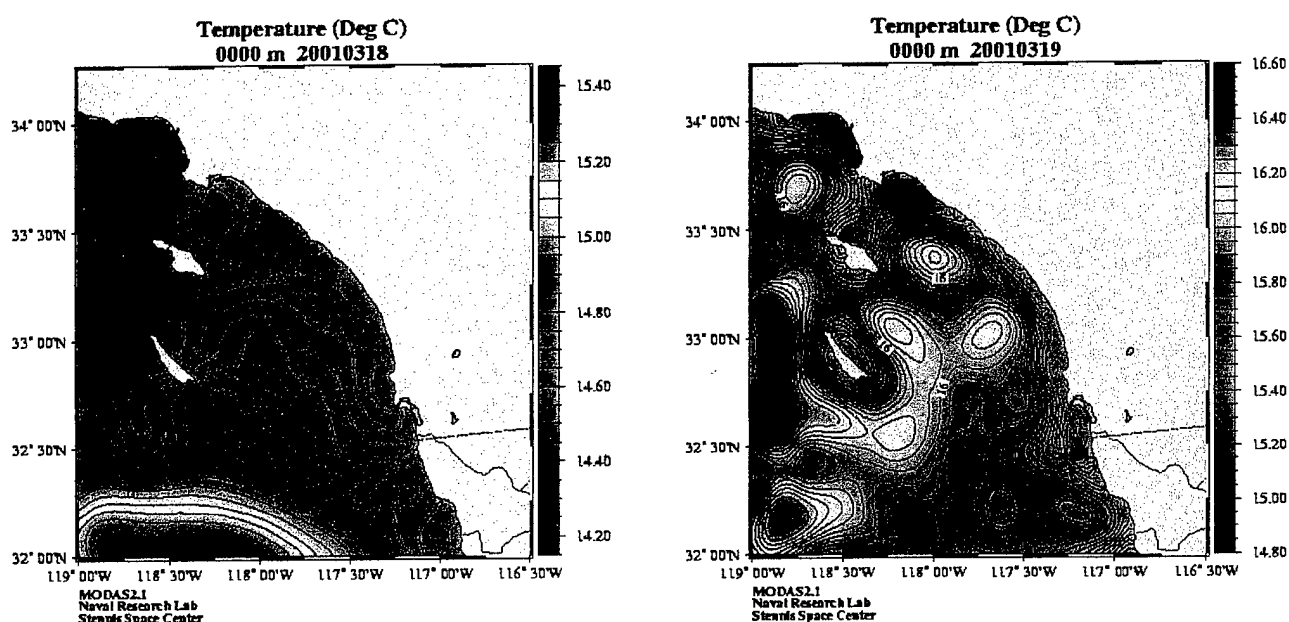


Fig. 1.: MODAS nowcast field from two consecutive days a) persistent cloud coverage, b) clear day. Due to the coastal environment, no altimetry data are assimilated.

2) Open Boundary Conditions. While MODAS estimates the baroclinic component under the geostrophic assumption, the barotropic velocities are often inadequate, primarily where it is not possible to estimate the dynamic height (i.e., transport) and make use of altimetry data. To partially remove the problem, NRLPOM has the capability of substituting MODAS barotropic field with the barotropic, non-tidal flow from other existing circulation models (Fig. 2). This approach offers three major advantages:

- The barotropic field can be estimated from a variety of models including layer,  $z$ ,  $\sigma$ , and hybrid-levels formulations.
- Only horizontal (no vertical) interpolation is required.
- Due to the short-term applications, it is not necessary to update the non-tidal reference values as the computations proceed (i.e., only one exchange of information between the models) (Fig. 3).

The major limitations are that the algorithm does not allow tidal-to-tidal model coupling, the procedure cannot be applied for long-term applications, and a severe mismatch may occur between the barotropic and baroclinic boundary velocities.

### The Monterey Bay Real-Time Simulations

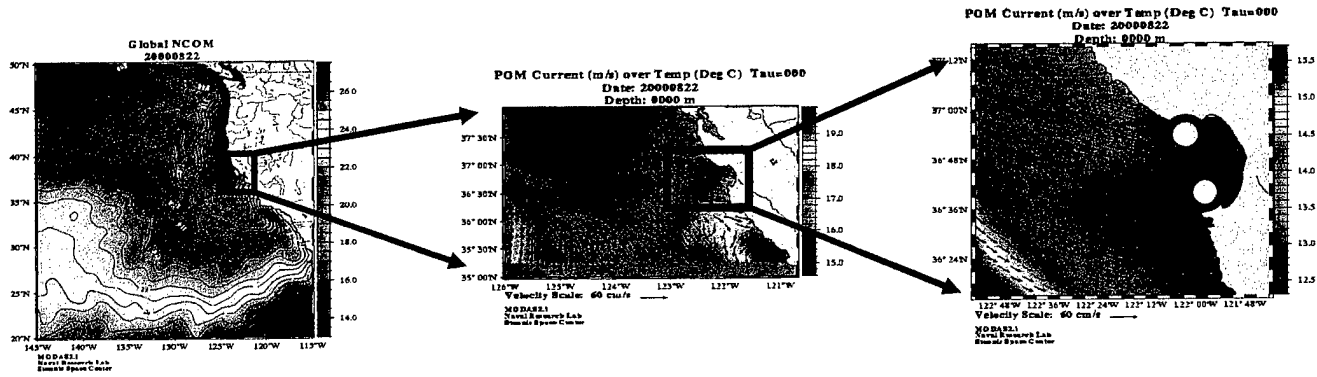


Fig. 2a. Example of model coupling: Global  $1/4^\circ$  NCOM (25 km resolution) provides transport values at the boundary of NRLPOM regional model for the California Current which provides transport values for the NRLPOM local model with tidal forcing.

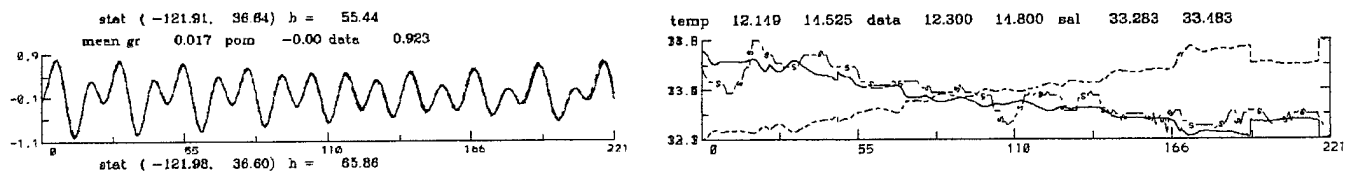


Fig. 2b: Model-data comparison with tide gauge and buoy measurements in the Monterey Bay area. The model solutions are from long-run forecasting simulations as previously described.

- 3) Tidal forcing. Flather's BC requires reference values for both elevation (SSE) and velocity. While SSE can be estimated from models of the tidal constituents, it is more difficult to acquire the velocity values. Since there exists a clamped tidal solution, the algorithm unfolds as follows:
  - SSE from the Grenoble Model is updated each baroclinic time step with zero reference tide velocities.
  - At the boundaries, SSE is nudged to Grenoble solution: with a typical 3-6 hrs. nudging time scale (the value was determined through numerical tests to yield adequate tidal amplitude of the interior points).

Figure 3 illustrates some model-data comparison in several coastal regions. The tide gauge data are from the NOAA Center for Operational Oceanographic Products and Services tide gauge stations, extracted from the web page: <http://www.co-ops.nos.noaa.gov/>.

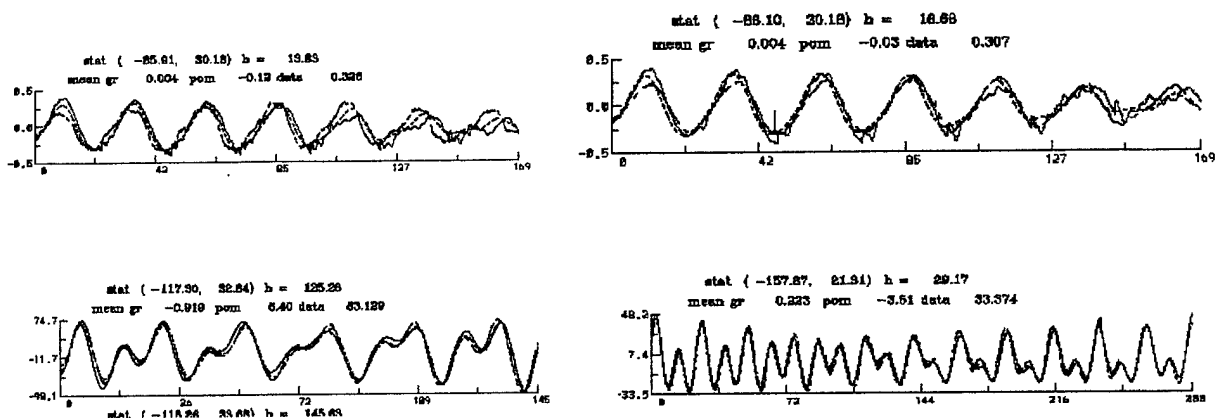


Fig. 3a: Comparison between the forecasted tidal amplitude and gauge data from several model simulations. A) Panama City, B) Pensacola, C) LaJolla, and D) Pearl Harbor.

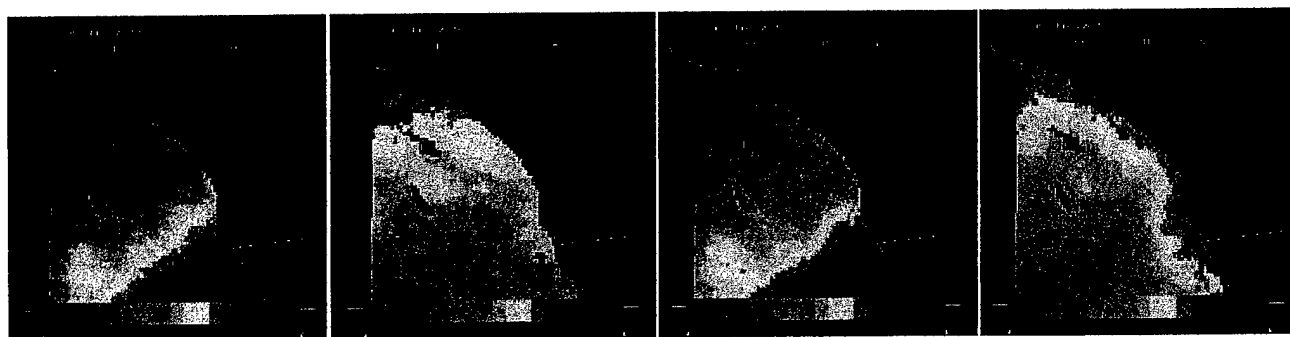


Fig. 3b: The residual tidal circulation on the Southern California, Santa Barbara Channel region. Snapshots are every 6-hour interval.

## IMPACT/APPLICATIONS

An earlier version of MODAS-NRLPOM is routinely applied at NAVO in several areas and configurations, ranging from basin-scale to inlets, from deep to coastal domains. MODAS-NRLPOM has been applied in support of the real-time Naval exercise Kernel Biltz 01 off the San Diego coast. The model is currently applied at NAVO in providing currents around the shallow Ehime Maru recovery site (specifically to assist in forecasting where oil and other items would drift).

## TRANSITION

Transition to NAVO is in progress.

## **RELATED PROJECTS**

This research provides a test bed for the development and evaluation the Distributed Environmental Forecast System (DMEFS) framework. The research is the result of an active collaboration with NRL CODE-7320. Related projects include:

- 6.4 SPAWAR On-Scene Tactical Ocean Forecast Capability (D. Fox)
- Relocatable Models (R. Preller)

**Acknowledgments:** This research would not have been possible without the contribution, collaboration and support of Mr. Daniel Fox of NRL Code 7320. We wish to thank Drs. C. Barron and R. Rhode, Ms. P. Posey, and Ms. J. Dastugue of NRL Code 7320 for their continuing assistance.